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ABSTRACT

Six variables have a significant effect on student engagement rates in middle school science activities: (1) teacher wait-time; (2) quality of teacher questioning; (3) cognitive level of teacher behavior; (4) classroom management; (5) student formal reasoning ability; and (6) student locus of control. Data suggest the importance of formal reasoning ability and locus of control as student attributes that affect engagement. Engagement rates appear to be enhanced when teacher questions are relevant, clear, and focused at a variety of cognitive levels. Higher rates of student engagement are associated with higher measures of classroom management and teaching behaviors that are at a higher cognitive level. (JD)

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The Relationships of Selected Dimensions of Teacher
Performance with Student Engagement

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THE RELATIONSHIPS OF SELECTED DIMENSIONS OF TEACHER PERFORMANCE WITH STUDENT ENGAGEMENT

Many variables influence student behavior and achievement in classrooms. Thus, in studies where an understanding of classroom learning is a concern the initial task is to identify variables that are logically or empirically related to outcomes and determine their separate and collective effects. Among the variables that have been identified as influential are cognitive level of questioning (Rosenshine and Furst, 1978), clarity (Good and Grouws, 1977), wait-time (Rowe, 1974) and classroom management (Brophy, 1979).

The importance of teacher questioning as a classroom process variable has been well documented in a number of studies and reviews (e.g., Winne, 1979; Hargie, 1978; Gall, 1970). Gall stated that the value of focusing on teacher's questions is that they are the basic unit underlying most methods of classroom teaching. Many researchers have focused on teacher questioning as a means of promoting student achievement. In particular, many studies have focused on the effects of higher cognitive level questions on achievement (c.f. Winne, 1979). Some results have shown a positive relationship (e.g., Hunkins, 1968; Kneip, 1977), others have shown no relationship (e.g., Riley, 1980; Wilen and Searles, 1977) and replicated studies have often shown contradictory outcomes (e.g., Buggey, 1971; Savage, 1972). Inconsistent findings such as these prompted Winne to remark that: "In a sense it is possible to ask whether the test for different effects has yet been done for higher cognitive questions."

From a logical viewpoint higher cognitive questions are not expected to be appropriate for all types of objectives. A common sense notion

suggests that the cognitive level of questioning should be matched to the cognitive level of the intended outcomes and that an optimal learning environment should contain a blend of high and low cognitive questions. The actual ratio of high to low questions should be dependent on the outcomes of concern and individual characteristics of learners. Higher level questions are of little value unless they have an impact on student engagement; thus the cognitive ability of the learner to perform the task required by the question is a variable that must be considered. For example, students with low formal reasoning ability may have difficulty responding to a question that requires synthesis, analysis or application.

Another variable that needs to be considered is the amount of time that students have to think about and develop a response to a higher level question. Rowe (1974) reported increased verbal inquiry behavior for teachers and students when a variable called wait-time was increased above three seconds. Wait-time was defined in terms of the duration of silent pauses between speakers. Teacher wait-time was also found to be related to science achievement (Tobin, 1980). Consideration of these findings suggests that an increase in questioning level should be accompanied by the use of an extended wait-time. The lack of a relationship between questioning level and achievement may be partially attributed to the use of a short wait-time during instruction. Rather than focusing on achievement, investigations might determine how student behavior is influenced by the use of higher level questions in conjunction with an extended wait-time.

Numerous studies have investigated the effects of teacher variables such as clarity, relevance, simplicity and vagueness on a variety of student outcomes. Land and Smith (1979) reported significant differences in student achievement that could be attributed to the presence of vagueness

terms and mazes (e.g., false starts, uncertainty in speech). Hillier, Fisher and Kaess (1969) also found vagueness to be significantly related to achievement. Good and Grouws (1977) reported a significant relationship between teacher clarity and student achievement. The variables investigated by these researchers were used as a basis for defining questioning relevance and questioning clarity. In this study, the effects of these variables, together with cognitive level of questioning and wait-time were assessed on student behavior and achievement.

By highlighting the importance of pupil learning experiences, the process-product model proposed by Medley, Soar and Soar (1975) (see Figure 1) provides several foci for classroom based research. Investigation of the adjacent cells in the model allows complex relationships between specified outcomes and teacher and student behaviors to be untangled.

(Include Figure 1 About Here)

This study investigated relationships between teacher and student behaviors in middle school science lessons with an emphasis on integrated process skills. The processes are intellectual skills which students use in the classroom as they collect and interpret data. Students use process skills to formulate responses to questions, to justify points of view, to explain events or procedures and to interpret or describe results. Since the objectives to be achieved were higher cognitive level skills, the model suggests that students need to engage in higher cognitive level behaviors to have appropriate practice on the objectives. The role of the teacher, therefore, is to develop a learning environment in which students can engage in the required behaviors.

The Medley et al. model is readily modified to incorporate student attributes that may affect classroom behavior and achievement (see Figure 2).



Figure 1. A process-product model for classroom learning.

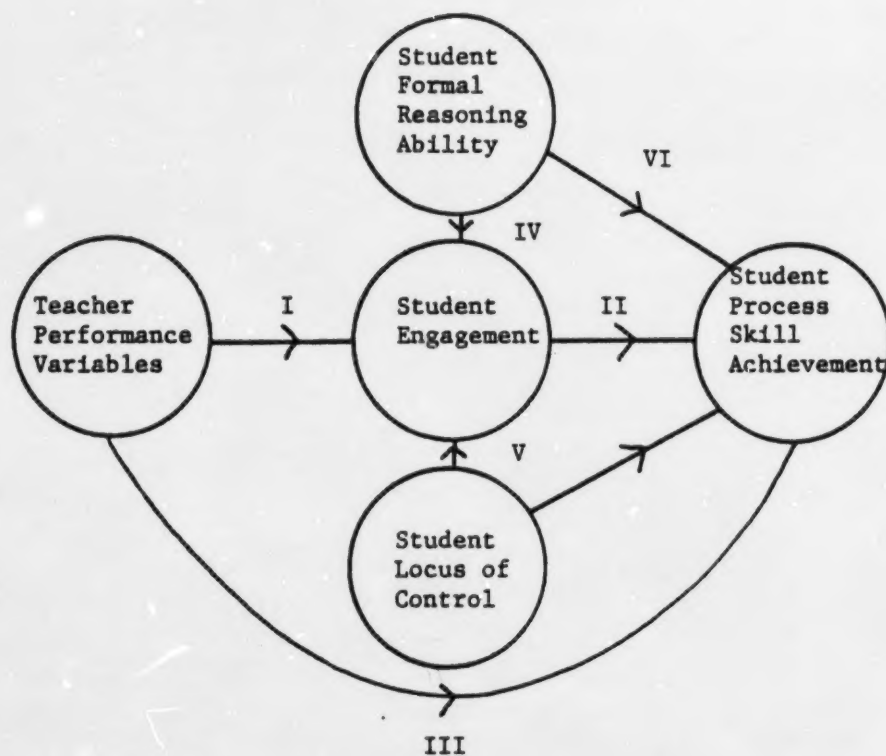


Figure 2. A process-product model for student achievement of science processes.

(Include Figure 2 About Here)

PURPOSE

The research reported in this paper is a component of a larger study in which the relationships shown in Figure 2 were investigated. The paper describes the relationships of selected teacher variables on student engagement rates in science classes. In each analysis student locus of control and formal reasoning ability were considered as personal attributes that were likely to influence the outcomes.

Six research questions were formulated as a basis for the study. The questions are related to components I, IV, and V of the model in Figure 2.

1. How is variation in teacher wait-time related to variation in student engagement? (I)
2. How is variation in the quality of teacher questioning related to variation in student engagement? (I)
3. How is variation in the cognitive level of teacher behavior related to variation in student engagement? (I)
4. How is variation in classroom management related to variation in student engagement? (I)
5. How is variation in student formal reasoning ability related to variation in student engagement? (IV)
6. How is variation in student locus of control related to variation in student engagement? (V)

RATIONALE

Through the enhancement of cognitive level, clarity and relevance of questioning in a sample of classes, concomitant variations in student engagement were expected to occur. The use of an increased wait-time should provide students with additional time to think, commence speaking and to complete a response. Thus, an extended wait-time in conjunction with higher quality questions should lead to higher levels of appropriate student engagement.

While all students are expected to benefit from increased wait-time, students with higher formal reasoning ability may use additional thinking time productively to formulate appropriate responses. Because of limitations in ability to think abstractly, students with lower levels of formal reasoning ability may have difficulty responding to higher level questions. For such students the provision of increased time to think may be of limited value and a greater incidence of off-task behavior could result.

Research has indicated (e.g., Davis and Phares, 1967) that students with an internal locus of control are more likely to engage in data gathering activities and make greater use of information than students with an external locus of control. Rotter and Mulry (1965) and Julian and Katz (1968) reported that students with an internal locus of control spent more time deliberating about their decisions and consequently took more time to arrive at a decision than students with an external locus of control. Thus, higher engagement rates are likely in extended wait-time classes for students with an internal locus of control.

Tobin, Capie, Ellett and Johnson (1980) reported a positive relationship between classroom management and student engagement. Thus, higher rates of engagement are expected in well managed classrooms. Unless satisfactory standards of classroom management are maintained, the use of high quality questioning and an extended wait-time are unlikely to promote student engagement or learning.

PROCEDURES

Thirteen intact classes from four middle schools in Clarke County, Georgia were selected to participate in the study. Five of the selected classes were from grade 8, four from grade 7, and four from grade 6.

The classes participating in the study were heterogeneous with respect to socio-economic status, race and intelligence. The range on each of these variables within each class was similar for all participant classes in accordance with a policy of heterogeneous grouping that was adopted in the school district. Sixty percent of the sample were from homes of high socio-economic status and 40 percent from homes of low socio-economic status. Sixty percent of the sample were white, 37 percent black and 3 percent were of other races.

Within each grade level, one class was assigned to one of four feedback groups defined on the basis of manipulation of questioning quality and/or teacher wait-time. The groups were:

1. extended teacher wait-time; high questioning quality:
2. extended teacher wait-time; normal quality of questioning;
3. normal teacher wait-time: high quality of questioning; and,
4. normal teacher wait-time; normal quality of questioning.

In grade 8, where five classes were involved, two classes were randomly assigned to group one.

Extended Teacher Wait-Time

Teachers in the extended wait-time groups were asked to maintain a mean wait-time between three and five seconds. After each lesson, the teachers in groups one and two received feedback on their mean teacher wait-time. The feedback was presented and discussed prior to each lesson with a view to maintaining an extended wait-time.

Quality of Questioning

Teachers in the high quality of questioning groups were asked to maintain a high level on three questioning variables: cognitive level,

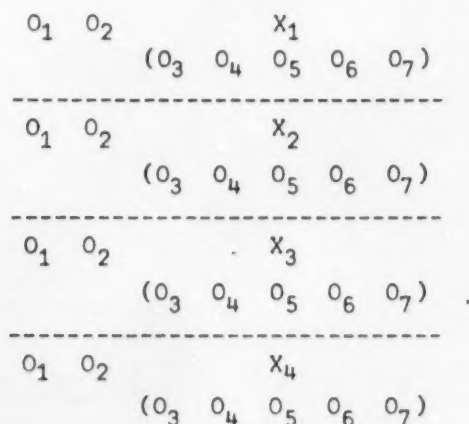
clarity and relevance. Written information was provided on the nature of each variable and after the first lesson, specific feedback was provided on the questions asked in the previous lesson. The feedback was presented and discussed prior to each lesson with a view to improving or maintaining questioning quality.

Placebo Feedback

So that all teachers in the study received feedback and consultation, a placebo feedback was administered. Teachers in group four received suggestions on what was to be taught prior to each lesson. Discussion usually focused on lesson plans or use of materials. The questioning variables and teacher wait-time were not discussed with teachers in this group.

Research Design

The research design may be represented using Campbell and Stanley (1966) notation in the following manner.



The symbols used in the above diagram represent the following measures and treatments:

O_1 = premeasure of locus of control;

O_2 = premeasure of formal reasoning;

- X_1 = extended wait-time, high quality of questioning;
- X_2 = extended wait-time, normal quality of questioning;
- X_3 = normal wait-time, high quality of questioning;
- X_4 = normal wait-time, normal quality of questioning;
- O_3 = student engagement measures;
- O_4 = classroom management measures;
- O_5 = index of teacher behavior measures;
- O_6 = teacher wait-time measures; and
- O_7 = questioning quality measures.

A sequence of eight science lessons was presented in each class over a two week period of time. Each lesson was developed from a learning hierarchy to promote the acquisition of twelve objectives related to hypothesizing, interpreting data, identifying and controlling variables and defining operationally. The algorithm used to develop the lessons for the study is fully described elsewhere (see Tobin and Capie, 1980a).

Selection of Subjects

A quasi-random sampling procedure was used to select 12 students from each class as data sources for academic engagement measures. Prior research (e.g., Chiappetta, 1976) suggested that only a small percentage of students would obtain high formal reasoning scores. To satisfactorily investigate the research questions however, a broad range of formal reasoning ability was required in the sample to be observed. Within each class, four students were randomly selected from those scoring greater than three on the Test of Logical Thinking (TOLT) (Tobin and Capie, 1980b), four students from those scoring two or three, and four students from those scoring less than two. The scores used for stratification were selected on the basis of prior research with middle school students (see

Tobin and Capie, 1980b). The stratifying procedure was adopted to assure that a satisfactory range of formal reasoning ability was represented in the sample. In classes where less than four students were represented in the highest category, additional students were selected from those scoring two or three on TOLT.

Since formal reasoning ability and locus of control are uncorrelated (Tobin and Capie, 1979), this sampling procedure did not systematically influence the locus of control data represented in the sample.

Data Analysis

The effectiveness of the feedback procedures was assessed using discriminant analysis with feedback group as a classification variable and wait-time, questioning relevance, questioning clarity and cognitive level of questioning as dependent variables. The purpose of this analysis was to determine whether the feedback procedures produced discernible differences between groups on the four variables. Thus, the percentage of agreement between feedback group membership and predicted group membership based on measures of the four manipulated variables is an indication of the extent to which the variables were successfully manipulated.

Continuous measures on all teacher and student variables were used in data analyses. Descriptive statistics were calculated for all variables and interrelations between variables were initially investigated with product moment correlations. Since the research questions were concerned with attributes of individuals, the units for statistical analyses were individual measures. As a result of the relatively large sample size, correlations of comparatively small magnitude were statistically significant; thus, a decision-rule was established whereby correlations with a magnitude of less than .3 were regarded as having no practical significance.

Because of significant relationships of achievement with attending and generalizing rates, further analyses were conducted on variables influencing these modes of engagement. Separate multiple regression analyses were used to determine the effects of teacher and student variables on student attending and generalizing respectively.

Variables

This section contains operational definitions for each of the variables measured in the study.

Quality of questioning and wait-time were measured from audio-tapes. Classroom management, the index of teacher behavior and student engagement were rated by direct observation of each lesson. Each of the above variables was measured by the same person.

The quality of questioning variables were assessed for each teacher on the basis of a sample of thirty questions randomly selected from audio-tapes of each lesson. The mean for each teacher was based on the grand mean over the sampled questions and all lessons. Generalizability coefficients (Cronbach, Gleser, Nanda, and Rajaratnam, 1972), for the measures obtained indicated that the data were dependable for differentiating teacher questioning quality and generalizing over questions and lessons. The coefficients obtained were: clarity, .91; relevance, .89; and, cognitive level, .87.

Cognitive Level of Questioning. The categories of engagement from Transactions in Science (TIS) (see Table 1) were used to rate each question according to the behavior it was intended to elicit. A weight (see Table 1) which reflected the position of the TIS category on a cognitive hierarchy was assigned to each question. An index, representing the cognitive level of questioning, was calculated as the mean over the sample of questions and all of the lessons.

Table 1
Definitions and Cognitive Weights for
Transactions in Science

Category	Definition	Cognitive Weight
1. Attending	Looking at the teacher, book, worksheet, paper, chalkboard, etc. Physically attending to a task.	-
2. Recalling	Responding to questions with recalled facts. Stating definitions. Stating names and/or terms without explaining their meaning. Stating matters of fact.	1
3. Collecting	Collecting data in an investigation. Copying material from books or the chalkboard, etc. Recording data in an investigation.	1
4. Comprehending	Explaining the meaning of a term. Naming data points on a graph. Describing graphic or tabular data. Reporting techniques. Reporting data. Representing data in a different mode.	2
5. Quantifying	Calculating relations between data. Reducing many bits of data to a representative value. Determining a scale for graphic representation of data. Reducing many bits of data to sub-groups. Classifying data into sub-groups.	2
6. Planning	Identifying variables that are relevant to a given problem. Identifying the dependent variable in an investigation. Identifying the variables that may affect the dependent variable in an investigation. Identifying the independent variable to be manipulated in an	3

investigation. Identifying procedures for manipulating the independent variable in an investigation. Identifying the variables to be controlled in an investigation. Identifying procedures for controlling variables in an investigation. Identifying methods of measuring the dependent variable in an investigation. Identifying variables to label the axes of a graph or to be the headings on a table.

- | | | |
|------------------|---|---|
| 7. Generalizing | Comparing data from an investigation. Identifying data that support an hypothesis. Interpolating between or extrapolating beyond data points in tables or graphs. Using data to construct an inference. Using data to construct an hypothesis. Justifying an explanation or a decision. | 3 |
| 8. Non-Cognitive | Non-cognitive behaviors that are goal-directed. e.g., collecting items of equipment. Assembling apparatus. | 0 |
| 9. Off-Task | Behaviors that are not goal-directed. e.g., reading a book while the teacher is explaining how to solve a problem. | 0 |

(Include Table 1 About Here)

Questioning Clarity. A clear question communicates precisely what is required of the learner. To the extent that lack of precision contributes to misunderstanding, a question was considered unclear. The presence of one or more of the following indicators suggested a lack of clarity.

1. Words that are difficult to understand were used in the question.
2. Excessive vocabulary was contained in the question.
3. Multiple questions were posed.
4. Complex sentence structure was evident in the question.
5. Tangles of words were present in the question.
6. Qualifiers were used in the question (e.g., almost, pretty much, quite a bit, possibly, etc.).
7. One or more false starts occurred when the question was posed.
8. Halts in speech disrupted the flow of the question.
9. Redundant information was contained in the question.

Each question was assigned a clarity rating using the following guidelines in conjunction with the nine indicator statements.

1. A rating of two was assigned to a clearly stated question.
2. A rating of one was assigned when the presence of one or more indicators contributed to slight imprecision. In this case there was no evidence of misunderstanding attributable to lack of clarity of the question.
3. A rating of zero was assigned when the presence of one or more indicators resulted in unclear presentation of the question.

An index, representing questioning clarity, was calculated as the mean over the sample of questions and all lessons.

Questioning Relevance. Relevance was defined in terms of the timeliness of a question and the match between the purpose of the question and the lesson objectives.

Untimely questions were characterized in the following way:

1. The question should have been asked at an earlier time in the lesson.
2. The question should have been asked at a later time in the lesson.
3. The question was repeated when it was not necessary to do so.
4. The question resulted in an undesirable change in the lesson.
5. The question interrupted another speaker.

Each question was assigned a relevance rating using the following guidelines.

1. A rating of two was assigned when: (a) there was a high level of concurrence between the purpose of the question and the instructional objectives; and, (b) the question was asked at an appropriate time.
2. If the question was asked at an inappropriate time, a rating of one or zero was assigned. Irrespective of timeliness, a rating of zero was made when there was little concurrence of the purpose of the question and the objectives.

An index representing questioning relevance was calculated as the mean over the sample of questions and all of the lessons.

Teacher Wait-Time. Wait-time was defined as the length of the pause preceding any teacher utterance. Figure 3 shows that teacher or student talk can precede the relevant pause.

(Include Figure 3 About Here)

As it was defined in this study, wait-time embraced all utterances that occurred in an instructional sequence. The following situations were relevant to the measurement of teacher wait-time:

Example 1:	Teacher talk	Pause	Teacher talk
Example 2:	Student talk	Pause	Teacher talk

Figure 3. Schematic representation of teacher wait-time.

1. when child dialogue was followed by a teacher utterance.
2. when a teacher utterance was followed by another teacher utterance.

Discourse that was extraneous to the lesson objectives, such as discipline or classroom organization moves, was not considered in the analysis. Wait-time was measured from audio-tapes of the lessons with an accuracy of one-tenth of a second using a servo-chart recorder.

Wait-time measuring points were randomly sampled from each audio-tape such that 30 wait-time measures were sampled throughout each lesson. The arithmetic mean of the relevant pauses was computed for each teacher for each lesson.

A generalizability coefficient of .96 was obtained for the wait-time measures used in the study.

Classroom Management. All teachers were rated on 25 performance indicators from the Teacher Performance Assessment Instruments (TPAI) (Capie, Johnson, Anderson, Ellett and Okey, 1979). The performance indicators assessed classroom procedures and interpersonal skills. A generalizability coefficient of .87 indicated that the measures were dependable for differentiating teacher performance. Factor score coefficients from a study involving a large sample of beginning teachers (Tobin, Capie, Ellett, and Johnson, 1980) were used to obtain a one-factor measure of classroom management for each teacher in the study. Thus, each performance indicator contributed to a single measure of classroom management.

Cognitive Level Index of Teacher Behavior. Teacher behavior was rated at 30 second intervals throughout each lesson. The predominant behavior to occur within each interval was categorized using TIS. The cognitive weight that was assigned to each TIS category was used to obtain a measure of the cognitive level of teacher behavior during the study.

A generalizability coefficient of .99 indicated that the data were dependable for differentiating categories of teacher behavior.

Academic Engagement

In this study the behavior of each student was observed for one lesson of every two using a time sampling procedure in which behavior was observed for four seconds during each 30 second interval. If more than one codable behavior occurred in the four second interval, the predominant behavior to occur in that interval was recorded. The order in which students were observed was randomly determined.

Frequency counts constituted the raw data for the analysis. To enable proportions to be calculated for each engagement category, behavior data for each student were pooled over the four lessons that were rated. The proportion of time allocated to each mode of engagement was used as the unit for analysis for hypotheses related to student engagement. A generalizability coefficient for differentiating students and generalizing over lessons was estimated for each engagement category (Table 2).

(Include Table 2 About Here)

Formal Reasoning Ability. Formal reasoning ability of students was measured with a multiple response, paper and pencil test developed for this study. The Test of Logical Thinking (TOLT) (Tobin and Capie, 1980b) consists of ten items which provide a measure of formal reasoning on five dimensions: proportional reasoning, controlling variables, combinatorial reasoning, probabilistic reasoning and correlational reasoning. Two items for each mode of thinking are contained in the test. The internal consistency reliability of TOLT was .85.

Locus of Control. The Intellectual Achievement Responsibility (IAR) scale (Crandall, Katkovsky, and Crandall, 1965) was used to obtain a measure of locus of control. The internal consistency reliability of the

Table 2

Generalizability Coefficients for Student
Engagement Data

Engagement Category	Generalizability Coefficient
Total Engagement	.92
Off-Task	.92
Attending	.91
Recalling	.57
Collecting	.89
Comprehending	.70
Quantifying	.25
Planning	.31
Generalizing	.66
Non-Cognitive	.36

locus of control scale was .66.

RESULTS

The results from the data analysis are presented in three sections below. The sections contain results related to the: effectiveness of feedback; relationships among the variables; and, multiple regression analyses.

Effectiveness of Feedback

Feedback group means for teacher wait-time and the quality of questioning variables are contained in Table 3. The discriminant analysis data indicated that for 12 of 13 teachers the feedback groups to which they were randomly assigned coincided with groups formed on the basis of measures of wait-time and questioning quality. The data in Table 4 indicate that one teacher from the quality of questioning feedback group (teacher three) was misclassified. The teacher's profile of wait-time and questioning data more closely resembled that of a teacher from the placebo feedback group.

(Include Tables 3 and 4 About Here)

Relationships between Variables

Descriptive data for each teacher variable are contained in Table 5. An indication of the interrelationships among these data can be obtained from the correlations reported in Table 6. Each of the 15 correlations reported was positive and nine were statistically significant at the five percent level. Clarity, relevance and cognitive level of questioning were each significantly related with classroom management; teacher wait-time, questioning relevance and management were significantly related with the index of teacher behavior; and, the three quality of questioning variables were significantly intercorrelated.

(Include Tables 5 and 6 About Here)

Table 3

Descriptive Statistics on Wait-Time and
Questioning Quality for Each
Feedback Group

	Mean	Standard Deviation
Group 1 (Wait-Time and Questioning)		
Wait-Time	3.97	0.24
Cognitive Level of Questioning	2.11	0.21
Questioning Clarity	1.79	0.04
Questioning Relevance	1.64	0.13
Group 2 (Wait-Time Only)		
Wait-Time	2.35	0.51
Cognitive Level of Questioning	2.01	0.35
Questioning Clarity	1.68	0.20
Questioning Relevance	1.53	0.32
Group 3 (Questioning Only)		
Wait-Time	1.22	0.31
Cognitive Level of Questioning	2.05	0.46
Questioning Clarity	1.77	0.17
Questioning Relevance	1.59	0.21
Group 4 (Placebo)		
Wait-Time	1.07	0.09
Cognitive Level of Questioning	1.65	0.30
Questioning Clarity	1.69	0.26
Questioning Relevance	1.50	0.32

Table 4

Posterior Probabilities of Group Membership
Based on Discriminant Analysis of Teacher
Wait-Time and Quality of Questioning

Teacher	Treatment Group*	Posterior Probability of Group Membership			
		1	2	3	4
1	1	1.00	.00	.00	.00
2	4	.00	.00	.19	.81
3	3	.00	.00	.16	.84
4	4	.00	.00	.27	.73
5	2	.00	1.00	.00	.00
6	1	1.00	.00	.00	.00
7	1	1.00	.00	.00	.00
8	3	.00	.00	.97	.03
9	1	1.00	.00	.00	.00
10	2	.00	1.00	.00	.00
11	4	.00	.00	.11	.89
12	2	.00	1.00	.00	.00
13	3	.00	.00	.94	.06

- *Group 1: extended wait-time; high questioning quality;
 Group 2: extended wait-time; normal questioning quality;
 Group 3: normal wait-time; high questioning quality;
 Group 4: normal wait-time; normal questioning quality.

Table 5

Measures of Classroom Process Variables

Teacher	Cognitive Level of Questioning	Questioning Clarity	Questioning Relevance	Wait-Time	Classroom Management	Cognitive Level Index of Teacher Behavior
1	2.08	1.79	1.54	4.14	19.36	0.58
2	1.62	1.62	1.61	0.96	11.60	0.58
3	1.52	1.60	1.43	0.88	17.52	0.54
4	1.37	1.48	1.14	1.11	18.62	0.46
5	2.27	1.77	1.62	2.78	18.62	0.52
6	2.33	1.79	1.74	3.68	17.14	0.70
7	2.20	1.83	1.77	3.87	3.89	0.56
8	2.23	1.79	1.52	1.31	- 4.07	0.54
9	1.84	1.74	1.52	4.19	18.62	0.71
10	1.61	1.45	1.18	1.79	15.24	0.59
11	1.96	1.98	1.75	1.13	12.50	0.59
12	2.15	1.83	1.80	2.48	5.26	0.65
13	2.39	1.93	1.83	1.48	12.27	0.62
Mean	1.97	1.74	1.57	2.29	12.81	0.59
Standard Deviation	0.34	0.16	0.22	1.29	7.16	0.07
Possible Score	3.00	2.00	2.00	No Limit	20.00	1.00

Table 6

Intercorrelations among Measures of Teacher Behavior

	1	2	3	4	5	6
1. Wait-Time	1.00					
2. Cognitive Level of Questioning	.45	1.00				
3. Relevance of Questioning	.28	.76***	1.00			
4. Clarity of Questioning	.26	.81***	.89***	1.00		
5. Management	.26	.54*	.59*	.52*	1.00	
6. Index of Teacher Behavior	.50*	.39	.51*	.40	.52*	1.00

* $p < .05$ ** $p < .01$ *** $p < .001$

The rates of student engagement are presented in Table 7. With the exception of attending (33 percent) and collecting (15 percent), the engagement rates for each category were low. The mean proportion of off-task time was approximately 37 percent. The mean proportion of the total time allocated to each category by teachers is also contained in Table 7.

(Include Table 7 About Here)

The data in Table 8 provide an indication of the range of engagement categories that occurred with three categories of teacher behavior. For example, teacher generalizing behaviors were associated with 55 percent student attending, 30 percent off-task behavior and only five percent generalizing.

(Include Table 8 About Here)

The correlations reported in Table 9 provide an indication of the relationships between the teacher variables and measures on each category of student engagement.

(Include Table 9 About Here)

Multiple Regression Analyses

Data analyses for the effects of teacher and student variables on attending and generalizing are presented separately in the following sections.

Attending. Classroom management, the cognitive level of teacher behavior and student locus of control together accounted for 26 percent of the variance in student attending. Each variable accounted for a significant proportion of the variance in the presence of other variables. The data from the multiple regression analysis are contained in Table 10.

(Include Table 10 About Here)

Table 7

Teacher Behaviors and Rates of Student Engagement

Engagement Category	Mean Teacher Percentage	Standard Deviation	Mean Student Percentage	Standard Deviation
Attending	Not Coded		33.12	14.97
Recalling	3.63	2.56	5.39	5.46
Collecting	21.72	8.33	14.63	8.83
Comprehending	22.26	5.50	4.54	3.79
Quantifying	3.83	2.31	0.51	0.90
Planning	16.55	4.67	0.38	0.72
Generalizing	17.07	5.70	1.10	1.51
Non-Cognitive	7.87	5.32	2.92	3.65
Total Engagement	92.82	4.77	62.54	22.50
Off-Task	7.18	4.77	37.41	22.50

Table 8

Separate Student Engagement Distributions for
Three Selected Teacher Behaviors*

Student Engagement	Teacher Behavior		
	Comprehending	Planning	Generalizing
Attending	31	59	55
Recalling	3	5	5
Collecting	4	0	2
Comprehending	13	1	2
Quantifying	0	0	0
Planning	0	4	0
Generalizing	0	0	5
Non-Cognitive	1	1	1
Off-Task	49	32	30

*The percentage of occurrence of each student engagement category is presented separately for each teacher behavior.

Table 9

Relationships of Teacher Variables with Student Engagement Rates
(N = 153)

	Wait-Time	Cognitive Level of Questioning	Questioning Relevance	Questioning Clarity	Classroom Management	Cognitive Level Index of Teacher Behavior
Attending	.23*	.29**	.27**	.28**	.40***	.42***
Recalling	.13	.36***	.36***	.34***	.12	.25**
Collecting	-.10	.03	.16	.29**	.42**	-.06
Comprehending	-.04	-.22*	-.13	-.16	.21*	-.07
Quantifying	-.12	-.11	.03	.10	.04	.02
Planning	-.15	.24*	.31***	.43***	.28**	.13
Generalizing	-.01	.03	-.08	.01	.14	.21*
Non-Cognitive	.01	-.25**	-.29**	-.24*	.07	.06

* $p < .01$ ** $p < .001$ *** $p < .0001$

Table 10

Multiple Regression Analysis of Student Rates of Attending on Student Locus of Control,
Classroom Management, and the Cognitive Level of Teacher Behavior

Source	ΔR^2	B	<u>df</u>	Sum of Squares	<u>F</u>	<u>p</u>
Management	.03	0.43	1	935.64	5.35	.022
Cognitive Level Index of Teacher Behavior	.19	71.29	1	2489.05	14.23	.000
Locus of Control	.03	0.78	1	1024.35	5.86	.017
Error			143	25015.06		
R-Square: 0.26						

The data in Table 11 indicate the presence of an interaction between teacher wait-time and classroom management. Attending behavior was highest when teacher wait-time was close to three seconds and classroom management measures were high. As wait-time increased above three seconds, the proportion of student attending diminished.

(Include Table 11 About Here)

Table 12 contains data on the quality of questioning variables and teacher wait-time. An interaction was obtained for each quality of questioning variable with teacher wait-time on the rate of student attending. High levels of questioning relevance and clarity in conjunction with teacher wait-time measures of approximately three seconds were associated with the highest proportions of student attending. Rates of attending decreased as wait-time measures increased beyond three seconds.

(Include Table 12 About Here)

Intermediate values of the cognitive level of questioning in conjunction with teacher wait-time measures of approximately three seconds resulted in increased rates of attending. The wait-time trend was similar to that described for questioning relevance and clarity. As the cognitive level of questioning increased above a value of approximately 2.1, however, attending rate diminished.

Generalizing. Five variables comprised a model that was significantly related to variation in student generalizing behavior. The cognitive level of teacher behavior, questioning clarity and relevance; and student formal reasoning and rate of attending together accounted for 22 percent of student generalizing behavior. The data in Table 13 indicate a positive relationship for each of the variables except for questioning relevance. As the relevance of the questions increased, the rate of student generalizing tended to decrease.

(Include Table 13 About Here)

Table 11

Multiple Regression Analysis of Student Rates of Attending on Teacher
Wait-Time and Classroom Management

Source	ΔR^2	B	<u>df</u>	Sum of Squares	<u>F</u>	<u>P</u>
Wait-Time (W)	.03	9.30	1	2385.99	13.63	.000
Management (M)	.16	1.65	1	4594.49	26.24	.000
W X M	.04	-0.55	1	1913.61	10.93	.001
Locus of Control	.02	0.78	1	1019.57	5.82	.017
Error			148	25215.79		
R-Square: 0.25						

Table 12

Multiple Regression Analysis of Student Rates of Attending on
Teacher Wait-Time and Questioning Quality

Source	ΔR^2	B	df	Sum of Squares	F	p
Cognitive Level of Questioning (C)	.09	47.67	1	7055.07	41.06	.0001
Wait-Time (W)	.06	45.70	1	5652.49	32.90	.0001
C x W	.10	-22.06	1	5414.54	31.51	.0001
Error			154	26460.76		
R-Square: 0.25						
Questioning Relevance (R)	.08	46.36	1	2562.91	12.99	.000
Wait-Time (W)	.06	29.06	1	1450.91	7.35	.008
R x W	.00	-17.04	1	1283.02	6.50	.012
Error			154	30393.88		
R-Square: 0.14						
Questioning Clarity (Cl)	.09	105.58	1	4212.39	22.55	.0001
Wait-Time (W)	.06	104.53	1	2971.51	15.91	.0001
Cl x W	.03	-57.93	1	2868.47	15.36	.0001
Error			154			
R-Square: 0.18						

Table 13
Multiple Regression Analysis of Student Generalizing Behavior
on Teacher and Student Variables

Source	ΔR^2	B	<u>df</u>	Sum of Squares	<u>F</u>	<u>p</u>
Cognitive Level Index of Teacher Behavior	.03	5.75	1	14.45	7.92	.006
Questioning Clarity	.04	4.68	1	15.88	8.70	.004
Questioning Relevance	.03	-4.80	1	29.28	16.05	.000
Formal Reasoning Ability	.03	0.18	1	11.63	6.37	.013
Attending	.08	0.02	1	11.13	6.10	.015
Error			141	257.26		
R-Square: 0.22						

The relationships of questioning quality and wait-time on student generalizing were similar to those obtained for student attending rates. The data in Table 14 indicate that the proportion of variance in attending that was attributable to the independent variable ranged from six to 14 percent. Thus, the trends that are evident in the data should be interpreted with caution.

(Include Table 14 About Here)

DISCUSSION

The three sections presented in the discussion are: effectiveness of feedback; relationships between variables; and multiple regression analyses.

Effectiveness of Feedback

The data from Table 3 and Table 4 suggest that the feedback procedures were effective in manipulating teacher wait-time and the quality of questioning variables. Since teachers were randomly assigned to feedback groups, variations that occurred in the dependent variables of interest may be attributed to variations in teacher wait-time and questioning quality. An indication of the effectiveness of the feedback in modifying teacher behavior was the high proportion of teachers whose group membership was confirmed by discriminant analysis together with the group means reported in Table 3. Although many teachers in non-feedback groups asked questions that were relevant, clear and at a high cognitive level, the group means for feedback groups were greater than the means of non-feedback groups on each questioning variable. The lower standard deviations associated with feedback groups on each questioning variable is also of interest. The consistent feedback apparently reduced the variation among teachers.

Higher wait-time means were obtained by the wait-time feedback groups than non-feedback groups. Wait-time was an easier variable to manipulate. The highest teacher wait-time for a non-feedback group was below the lowest

Table 14

Multiple Regression Analysis of Student Rates of Generalizing on
Teacher Wait-Time and Questioning Quality

Source	ΔR^2	B	df	Sum of Squares	F	P
Cognitive Level of Questioning	.00	3.79	1	44.60	22.35	.0001
Wait-Time	.00	4.21	1	48.19	24.15	.0001
C x W	.14	-2.12	1	49.99	25.05	.0001
Error			154	307.30		
R-Square: 0.14						
Questioning Relevance (R)	.00	3.17	1	11.99	5.50	.020
Wait-Time (W)	.00	3.43	1	20.26	9.29	.003
R x W	.06	-2.14	1	20.28	9.29	.003
Error			154	335.95		
R-Square: 0.06						
Questioning Clarity (C1)	.00	10.85	1	44.45	22.10	.0001
Wait-Time (W)	.00	13.33	1	48.36	24.05	.0001
C1 x W	.14	-7.54	1	48.55	24.14	.0001
Error			154	309.70		
R-Square: 0.14						

teacher wait-time from a wait-time feedback group.

Relationships between Variables

The data in Table 5 show that the standard deviation for the index of teacher behavior and the cognitive level, clarity and relevance of questioning were comparatively low. This may be attributed to the provision for all teachers of detailed lesson plans which probably reduced between teacher variation. Despite the lack of variability, the generalizability coefficients indicate that the data were dependable for answering questions that required teachers to be differentiated.

The measures on the teacher variables were highly correlated (Table 6). An exception was teacher wait-time, which was significantly correlated with only one other variable, the cognitive level of teacher behavior.

Although the average percentage of student engaged time was high, the range was from five percent to 98 percent engaged time. Thus for individual students there was considerable opportunity to increase engagement rates. The proportion of time allocated to each category by teachers (see Table 7) indicates a discrepancy between the proportion of the total time allocated and actual student engagement rates for planning, generalizing and comprehending. The principal mode of student engagement on these categories was by attending to teacher instruction. For example, only five percent of the total time that teachers allocated for generalizing involved student generalizing behavior (see Table 8). Fifty-five percent of the time students were attending and 30 percent of the time they were off-task. The results were similar for planning. Students used two percent of the allocated time for overt planning. Fifty-nine percent of the time students were attending to teacher planning and 32 percent of the time they were off-task. These data suggest teacher centered instruction with student attending as the principal mode of objectives-related engagement.

The off-task category is an area in need of research. Clearly there are categories of off-task behavior that are of greater concern than others. For example, a degree of attending is possible as a student draws a picture or gazes through a window, however, attending is unlikely when students engage in disruptive activity, or talk with other students.

From the correlations reported in Table 9 there is evidence to suggest that questioning was used to focus student engagement on objectives related behaviors. Since many of the objectives were related to planning, questioning represented a means of eliciting student planning behavior. Significant correlations suggest that in classrooms where questions are clear and relevant, higher rates of planning occurred. Each of the questioning variables was positively related to the incidence of recalling behavior. Thus rates of pupil recalling were higher in classes where questions tended to be relevant to the objectives, clearly stated and referenced at a higher cognitive level.

Pupil attending was positively related with each teacher variable. This is an important outcome since attending was the predominant mode of engagement. The strongest correlates of attending were classroom management and the index of teacher behavior.

Classroom management was also significantly related to the incidence of data collecting. Where classroom management measures were higher, student data collecting was more prevalent.

Multiple Regression Analyses

The multiple regression analyses allowed the effects of teacher and student variables on attending and generalizing to be investigated concomitantly. Thus, three significant main effects were confirmed with the data in Table 10. Students with a higher internal locus of control tended to have higher attending rates; and, attending rates were higher when the

cognitive level of teacher behavior and classroom management measures were higher.

The effects of the manipulated variables on attending were consistent. Significant interactions were obtained for teacher wait-time with: classroom management; cognitive level of questioning; questioning relevance; and, questioning clarity. In all cases intermediate wait-time values were favored over short and long wait-time values. Indeed, when intermediate values of wait-time were maintained, attending rates were highest when measures of classroom management, questioning relevance and questioning clarity were high. High attending rates were also obtained when a wait-time of approximately three seconds was used with intermediate values of the cognitive level of teacher questioning index.

Although the proportion of the variance attributable to the model was often small in the above analyses, the results are somewhat strengthened by the analysis for the rates of student generalizing contained in Table 13. In each case a significant interaction was obtained. The interpretations of the interactions were almost identical with those applicable to attending rates.

One implication of the interactions reported with wait-time is that the effects of questioning quality need to be referenced to teacher wait-time. If the interactions are replicable, wait-time would have to be held constant for the effects of questioning quality to be consistently observed. This result has implications for implementing questioning training programs or conducting further research on questioning or wait-time.

CONCLUSION

The results from this study indicate that teacher behaviors can influence student engagement rates in middle school science activities. Each of the six teacher variables investigated in the study had a significant effect on

engagement rates. The data also suggested the importance of formal reasoning ability and locus of control as student attributes that affect engagement.

Through manipulation, an optimal teacher wait-time of approximately three seconds was determined for promoting attending and generalizing rates.

Questioning quality was also manipulated. The analyses suggested that engagement rates were enhanced when teacher questions were relevant, clear and focused at a variety of cognitive levels.

Non-manipulated teacher variables also influenced student engagement. Higher rates of student engagement were associated with higher measures of classroom management and teaching behaviors that were at a higher cognitive level.

Locus of control and formal reasoning ability are variables that should be considered when teaching strategies are planned or when classroom research is conducted. Student locus of control influences student attending rates. Higher rates of attending were associated with students with a greater internal locus of control. Since the rate of attending was related to the rate of generalizing behavior, locus of control has an indirect effect on generalizing.

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